1 Rec'd PCT/PTO 31 JUL 2000

Wood component and a method for the production and application of the same

09/509808

Description

The invention relates to a wood component in which the wood has altered properties in geometrically defined areas. The invention also relates to a method for producing such components and to the application of said component. The invention can be employed in the woodworking and wood processing industries, in the building and construction industries, and in the craft and trade.

In woodworking, lasers are used for, in addition to surveying processes, cutting and piercing processes. A novel application field is the removal of material using laser irradiation. Seltman, J.: Freilegen der Holzstruktur durch UV-Bestrahlung (Laying bare of the wood structure by UV-irradiation), Holz als Roh- und Werkstoff, Springer-Verlag, 53(1995), pp. 225–228; and Panzner, M. et al.: Experimental Investigation of the Laser Ablation Process on Wood Surfaces, Fourth International Conference on Laser Ablation COLA, Monterey, California, 1997, describe different possibilities and methods for the removal of the wood layer spoiled by mechanical removing processes using electromagnetic beams of different wavelengths.

From DE 94 02 681.5 U1, a device is known for the processing of glass, plastics, semiconductors, wood or ceramics, which uses laser radiation from a laser radiation source that emits laser radiation in form of a laser beam, focussing this laser radiation through a focussing optical system onto a glass, plastic, semiconductor, wood or ceramic material component. This device is characterized in that the laser radiation used has a wavelength of 1.4 µm to 3.0 µm.

This device is designed to enable an effective removing mechanism which is designed to heat the material to be processed very heavily in the range of wavelengths of 1.4 µm to 3.0 µm so that so-called micro-explosions occur. The heated material is removed. This process is used for marking components or generating mechanical stresses in glass tubes to subsequently break them in a melting zone.

In DE 40 33 255 A1 a method is described that is designed to upgrade wood veneers for visual effect by emphasizing the grain. This is reached by pyrolytic browning of the wood surface using IR-radiation. The alterations following the laser cutting of wood and wood materials were investigated, among others, by Parameswaran, N.: Feinstrukturelle Veränderungen

an durch Laserstrahl getrennten Schnittflächen von Holz und Holzwerkstoffen (Fine-structural alterations of laser-cut surfaces of wood and wood materials), Holz als Roh- und Werkstoff, Berlin 40(1982)11, pp. 421–428, who found the following: The brown to black colour of the cutting surfaces is due to the mainly thermal cutting process and typical of a pyrolysis in the cellular areas of separating. A surface largely melted down is produced which very much reduces the diameters of the cell lumina. The high temperatures in the cutting kerf (approx. 700 °C, Arai et al. 1979) lead to a gradual transformation of the wall components into a glassy body. Back, E.L.: Cellulose bei hohen Temperaturen: Selbstvernetzung ... (Cellulose at high temperatures: self-cross-linking ...), Das Papier, 27(1973), pp. 475–483, theoretically determined the melting temperature of cellulose of approx. 450 °C based on the glass temperature. Further, he found that melting without pyrolytic side effects will only be possible if heating and cooling occur in a sufficiently short period of time.

The above-mentioned melting processes when processing wood are considered to be adverse side effects. To date, no alterations of specific wood properties has been created.

In addition to the typical pyrolytical degradation processes when wood is laser-processed, melting is also known as a secondary transformation process. As a rule, melted areas are considered negative concerning the quality of the wood surface processed. Additionally, the pyrolytical degradation products generated in processing are held and solidified in the melt. Known methods, such as laser dividing, confine theirselves to evaporating wood substance by thermal or photochemical coupling of the laser during processing. Thereby, the alteration of the wood structure in the areas adjacent to the processing zone is arbitrary. Degradation processes are not controllable, can hardly be avoided, and lead to a reduced quality of the wood processed in this way. Different methods, such as plasma processing (DE 41 35 697 A1), require much effort to prepare the wood and complicated jigs, which prevents the industrial-scale application.

It is the objective of this invention to describe a wood component as well as a method for the production and application of said component, in which, in geometrically defined areas, the wood has altered properties such that chemically and physically, systematically altered properties of the wood surface follow. This is to avoid any treatment of the wood surface otherwise necessary, and to open a number of new possible uses and fields of application of wood.

According to the invention, the problem is solved using a wood component having the properties listed in Claim 1. A great number of component versions follow from the dependent claims. Further, the problem is solved using a process having the properties listed in Claim

11. Versions of the process follow from the dependent claims. Applications of the component follow from the Claims 22 to 28.

The wood component has altered properties in geometrically defined areas. According to the invention, the geometrically defined areas have exclusively the properties of solidified wood melts. In the context of the dependent Claims 2 to 10 it follows that said areas are single or several wood cells or single or several cell walls. From the melting together, alterations of properties of physical and chemical nature as well as tailored alterations of the deformation behaviour follow.

According to the Claims 22 to 28, the melt can be used for the production of joints of wood components and/or wood particles, or, respectively, reinforcements can be incorporated into the melt.

The main constituents of wood, cellulose, lignin and hemicelluloses, similar to other polymers have no melting point but there is a wide transition interval in phase transformation. In contrast to plastics, wood has no homogeneous structure and, hence, no softening point but a softening temperature range. In wood, thermal degradation processes already start at temperatures lower than 100 °C. However, the critical factor for the beginning and progress of pyrolysis is the duration of heat influence, since pyrolysis is a continuous course of successive degradation processes. Softening starts at temperatures about 100 °C, progressing with a quickly decreasing degree of polymerization of the chains and beginning plasticization. Molten wood is characterized in that it has a low degree of polymerization, increased proportion of amorphous substance, lost fibrillar structure of the cellulose and typical cell structure, homogenization and increased melting temperature when repeatedly heated.

Accordingly, the method to Claim 11 for the production of wood components is established such that the geometrically defined areas are melted by contact-free, short-time, preferably within less than or equal 50 ms, high energy input, so that the degree of polymerization of the chains decreases quickly and plasticization begins, and the melt solidifies within this period of time.

Advantageously, laser light is used as the electromagnetic radiation. The scope of the interaction zone, the interaction period and the intensity are realized by a combination of the relative movement between beam and workpiece as well as through methods of dynamic beam forming. Processing is in a gas atmosphere defined by composition, pressure and temperature. Heating can be in an inert gas atmosphere as well as in free atmosphere. The process of the invention can be combined with other methods of woodworking, e.g. mechanical processing.

Melting can be used within a defined time regime shortly before, during, or shortly after processing using another method.

From the invention, the following advantages result. Melting makes possible to change the structure of wood. Closing the wood cells directly leads to a decrease of the specific surface and the capillary take-up of humidity is reduced, or prevented, respectively. Wood and wood particles can be joined with each other by welding without any, or using solely wood-inherent (e.g. lignin) filling materials. By melting, wood can be joined with other materials, especially transparent polymers or fibrous materials. Melting is possible in a locally limited space or on a complete surface, whereby the proportion of melted volume has a geometrically defined magnitude on or below the surface, thus also defining the degree of alteration of physical and/or chemical properties. By melting, tailored physical and/or chemical alterations are produced in the wood. To realize this, also extraneous substances can be melted into the wood. Said extraneous substances can be particles and/or pigments. Before the melting process they are applied into or onto the wood through, for example, impregnating, immersing, coating, or during the melting process, for example, by means of a gas or powder beam. The diffusion properties of the wood to ambient media are changed. The diffusion properties in the main cutting directions of the wood are essentially homogeneous in melted areas. Melting leads to hydrophobing of the wood surface. Due to the tailored physical and/or chemical alterations, melted wood has an improved resistance to wood pest. Hardness and abrasion resistance of the wood surface can be adjusted. The optical properties (absorptivity, reflectivity and diffusing power) of the wood surface are deliberately altered. The lustre of melted wood is clearly different from that of unmelted wood. Softening of wood substance in the range of glass temperature offers novel possibilities for the deformation of wood.

In the following, the invention is further explained by examples of embodiment.

In order to protect the end of an 8 cm x 10 cm cross-sectioned wood beam from capillary water absorption, a closed surface of melted wood with a maximum thickness of 0.5 mm was produced in the range of the cross-cut grain. To produce this melted area the laser beam of a continuous CO_2-laser with a power of 2500 W and a laser spot diameter of 6 mm was meandered over the cross-cut surface to be processed of the beam end using a double-mirror scanner, with a track overlap of 10 percent and a velocity of 6 m/s.

In order to produce a homogeneous, closed melted zone with a thickness of more than 0.4 mm, the cell structure within the geometrically defined area must be abolished. Therefore, the wavelength and duration of the laser action were chosen such that the solid wood constituents were melted to a depth of approx. 0.8 mm.

The decreased capillary water absorption was evaluated by wetting with a defined water volume and measurement of the time until the complete penetration of the water. The investigation of the melted wood surface showed a penetration time prolonged by the factor 7.1.

Two spruce veneers 3 were welded together by melting of the lignin contained in the wood.

To this end, the veneers 3, first, were smoothed by ironing and fixed in a suitable fixture so that they lie close together without any clearance over the whole weld length.

To produce a weld 5 the laser beam 2 of a continuous CO_2-laser with a power of 2500 W, a spot diameter of 13 mm and a velocity of 12 m/s was linearly moved over the prepared weld area.

In order to produce a homogeneous closed weld 5 of a thickness of, at least, 0.5 mm, the cell structure within the geometrically defined area must be abolished. Therefore, the wavelength and duration of the laser beam 2 were chosen such that the solid wood constituents were melted to a depth of approx. 2 mm.

After processing, both veneers 3 are joined with each other by the weld 5. After separating the two veneers from each other, the microscope clearly shows a fracture edge over the whole weld length. Below the fracture edge a homogeneous melt layer is observed. The cell structure is abolished down to a depth of 0.4 mm.

Nomenclature

1	Beam guiding
2	Laser beam
3	Veneer
4	Processing direction
5	Weld
6	Melt